Micrometer scale capacitors for a new generation of computer memory

Profs. A. Gruverman & A. Kingon,
North Carolina State University, DMR 0235632

Micrometer scale ferroelectric capacitors are core elements of a new type of Nonvolatile Ferroelectric Random Access Memories (FeRAM) that can be used in portable computers, in electronic commerce and information security management. In spite of research that spanned a period of 60 years, surprisingly little is known about the physical mechanism of write/read operations in these capacitors. Piezoresponse Force Microscopy (PFM) allowed for the first time to look inside an individual capacitor by detecting its domain structure and to find out how different parts of the capacitor respond to the driving voltage. Figure 1 shows an array of 8 FeRAM $Pb(zr,Ti)O_3$ capacitors two of which have been written by an external voltage into positive and negative polarization states that correspond to "0" and "1" of computer logic. This information is obtained by detecting the normal component of spontaneous polarization. To understand the reliability behavior of the FeRAM device, the in-plane component of polarization needs to be detected as well. Figure 2 shows the color representation of the in-plane polarization of the black capacitor from Fig.1 and its relation to crystallographic axes. (A.Gruverman et al, APL 82, 3071 (2003); B. J. Rodriguez et al, J. Appl. Phys. 95, 1958 (2004)).

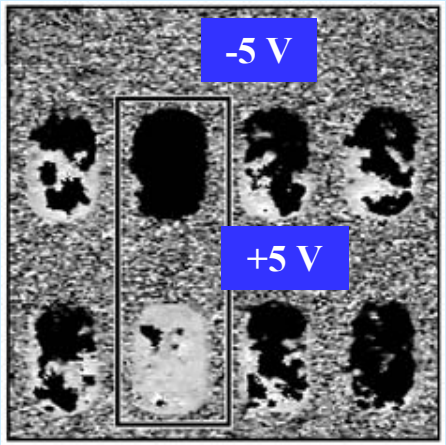
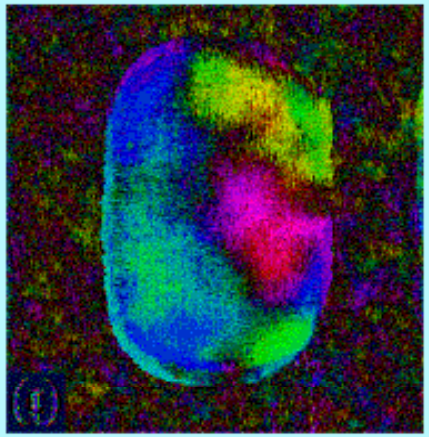


Fig.1



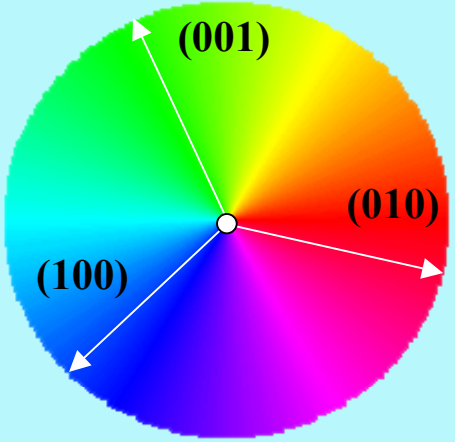
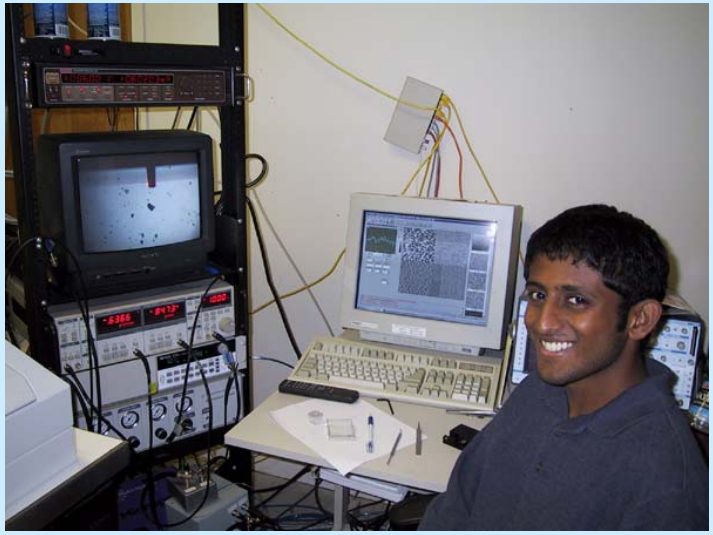


Fig.2

Color representation courtesy of S. Kalinin and A. Borisevich, ONRL

Students participate in state-of-the-art SPM research
Prof. A. Gruverman, Prof. A. Kingon,
North Carolina State University, DMR02-35632

The program involves two graduate students, two REU students and one intern student from Germany. This project provides an opportunity for students to work on a project which involves complicated multidisciplinary research that helps them to gain the first-hand knowledge of using scanning probe microscopy (SPM) for development of a new generation of memory devices. The students learn the principles of SFM and work together on nanoscale characterization of functional materials and electronic devices. This provides students with new expertise in the field of nanoscience and technology.



Three students have co-authored publications (5 in total) and project reports. One graduate student gave two oral presentations at the major international conferences (10th European Meeting on Ferroelectricity in Cambridge, UK, and MRS 2003 Fall Meeting in Boston). The program is essential for engineering efforts to improve the reliability properties of FeRAM devices. It allows students to participate in joint research with major semiconductor companies, such as Fujitsu, and to better understand the challenges and competition facing the new memory devices. One student visited Fujitsu Laboratories in Japan to help in setting up a PFM-based probe station for testing FeRAM capacitors.